ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

Vaccines Efficacy against Delta and Omicron Variants: A Comparative Study of Severe Acute Respiratory Syndrome CoronaVirus 2 (SARS-CoV-2) Vaccines

Claire G. Beringuela [1]; Dianna Jhent S. Cullamar [1]; Levy Donor [1]; Czedrick Khien S. Mongaya [1]; Gecelene C. Estorico [1] [2]
Civil and Allied Department, Chemical Technology Department
[1] Technological University of the Philippines – Taguig Metro Manila
[2] De La Salle University of the Philippines – Dasmariñas

Abstract:- The SARS-CoV-2 pandemic has necessitated the rapid development and deployment of effective vaccines. This systematic review included articles published between 2019 and 2024 that focused on comparing the different vaccines against SARS-CoV-2 and its two variants: omicron and delta. Articles and scientific papers were selected based on originality, full-text availability, and English language. Excluded were case studies, reviews without data, or articles lacking full text or English translation. All relevant studies were systematically selected from Google Scholar, ResearchGate, Elsevier, Springer, and Academia.edu to identify relevant research exploring the six selected vaccines. The collected review utilized and identified a total of 33 studies. The researchers were able to use 17 of these studies for a more in-depth quantitative analysis. The qualitative analysis of all 16 studies revealed that pain and swelling in the injection area, headache, muscle pain, and fatigue are the most frequently observed side effects of vaccines on humans. This systematic review aims to comprehensively compare the efficacy of the vaccines and their side effects and their efficacy rate to omicron and delta variants. By conducting a rigorous analysis of existing literature, the researchers evaluate the efficacy of the vaccines and how they respond to omicron and delta variants when it comes to efficacy as well. The review will focus on key outcomes such as doses and frequencies, vaccine efficacy based on Phase III clinical trials, and side effects. Understanding the comparative strengths and limitations of different vaccines will inform public health and optimize vaccination strategies to mitigate the ongoing pandemic.

Keywords:- *Boosters, Efficacy, Vaccine, Variants, Virus.*

I. INTRODUCTION

The advent of Severe Acute Respiratory Syndrome CoronaVirus 2 (SARS-CoV-2) in late 2019 signaled the start of a global pandemic with far-reaching ramifications for public health, economics, and civilizations around the world. To confront this unusual virus, scientists and researchers raced to create effective vaccinations that could avoid infection, hospitalization, and serious illness. In an extraordinary effort, several vaccinations were rapidly produced and deployed, providing optimism for pandemic control (Ciotti, M., et al. 2020).

On the other hand, the landscape of SARS-CoV-2 vaccines is complicated and dynamic, with a wide range of platforms and formulations available. Development began in early January 2020, when the genetic sequence of the virus was discovered, and it developed at in incredible rate: a phase I trial began in March 2020, and there are already over 180 vaccines in development. Statistics from phase I and phase II trials were already accessible to several vaccine candidates, and several have progressed to phase III trials (Krammer, F.2020).

While the preliminary findings were encouraging, further research is needed to assess the long-term durability of vaccine-induced immunity, especially in the face of new SARS-CoV-2 variations. More importantly, questions persist about the best immunization regimens, booster dosages, and vaccine efficacy in specific populations, such as the elderly people and immunocompromised individuals.

Understanding the comparative efficacy, safety, and immunogenicity of these vaccines is crucial for informing public health, optimizing vaccination strategies in the future, and ensuring equitable access to protection. This systematic review aims to provide a comprehensive analysis of the available evidence on different SARS-CoV-2 vaccines, with a particular focus on their overall performance. By critically evaluating the existing literature, this review will contribute to a deeper understanding of the strengths and limitations of various vaccine options and support evidence-based vaccination practices.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

II. METHDOLOGY

This study utilized a systematic review approach, using the widely accepted PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. PRISMA was used to rigorously select relevant publications released between 2019 and 2024 comparing vaccinations against SARS-CoV-2.

A. Data Sources

Using the PRISMA guidelines, all relevant published material was carefully selected from multiple widely recognized search databases, Google Scholar, ResearchGate, Elsevier, Springer, and Academia.edu.

B. Literature Search

To maximize a successful search strategy, the aforementioned databases' search engine used appropriate keywords and Boolean operators such as AND or OR. Three sets of keywords were entered and searched in the online databases. The keywords were categorized into five distinct groups.

The first group focused on the concept of boosters, including terms like "post-vaccination boosters," "protocol boosters," "COVID-19 boosters," and "pandemic boosters." This group emphasized the idea of additional doses of the vaccine. The second group centered around the efficacy of the vaccine, using terms such as such as "efficacy of vaccine" and "vaccine efficiency". These keywords highlighted the effectiveness and safety of the vaccine in preventing COVID-19 infection. The third group focused on the vaccines themselves, employing terms like "COVID-19 vaccine," "SARS-CoV-2 vaccination," "Janssen," "Moderna," "Astrazeneca," "Gamaleya Sputnik 5," "Pfizer," "SinoVac," and "COVID-19 vaccines clinical trials." This group directly addressed the specific vaccine used to combat COVID-19. The fourth group concentrated on the virus that causes COVID-19, using terms like "COVID-19 virus" and "SARS-CoV-2 virus." This group provided information about the nature of the virus itself.

Finally, the fifth group focused on the different variants of the COVID-19 virus, including terms like "omicron COVID variants," "delta COVID variants," and "COVID-19 variants." This group addressed the evolving nature of the virus and its potential impact on vaccine efficacy and public health measures.

Google Scholar, ResearchGate, Elsevier, Springer, and Academia.edu search results were limited to research and review publications authored in English and published between 2019 and 2024. During the initial literature search, all research publications found in databases were selected based on their titles, authors, publication dates, and journals to exclude duplicates. To eliminate irrelevant studies, the remaining papers underwent abstract and full text screening for qualifying criteria.

C. Inclusion and Exclusion

All relevant articles included in this review was classified with respect to: (1) studies that addressed the efficacy rates of the six vaccines (Janssen, Moderna, Astrazeneca, Gamaleya Sputnik 5, Pfizer, and SinoVac); (2) studies that identified the countries that approved each vaccine; (3) studies of efficacy of vaccines against omicron and delta variant; (4) studies that evaluated the side effects of each vaccine; (5) studies conducted and published between 2019 and 2024; (6) original studies published as research articles or review articles; (7) original articles with full text and (8) published in English language or have an English translation.

Studies were excluded if they (1) were case series, case reports or narrative reviews; (2) lack corresponding outcome parameters or research data or (3) do not have available full text or (4) no English translation.

D. Search Results

A total of 45 studies were initially identified using Google Scholar, ResearchGate, Elsevier, Springer, and Academia.edu's search terms. This online databases' search results were limited to research and review articles written in English and published between 2019 and 2024, excluding 5 studies from the first search results. Therefore, only 40 research publications remained and were screened according to inclusion criteria. After removing articles based on relevancy, only 33 remained for eligibility. A total of sixteen studies were eventually included in the qualitative analysis, while only seventeen studies were included in the quantitative analysis after further screening and evaluating the eligibility based on the contents of titles and abstracts and the availability of full text materials. The PRISMA flow diagram (See Fig. 1) illustrates the steps of study selection and findings.

E. Data Extraction

In this paper, 33 studies were chosen from a pool of 45 articles based on the established eligibility criteria. The systematic review encompassed various studies conducted around the world. Pertinent data and information were gathered from these studies throughout the review process.

The information and data extracted from 45 studies include efficacy rate of the six vaccines (Janssen, Moderna, Astrazeneca, Gamaleya Sputnik 5, Pfizer, and SinoVac), the total number of countries that approved a certain vaccine, efficacy of vaccines in omicron and delta variant, and lastly, the side effects associated with each vaccine.

F. Statistical Analysis

After tabulating and assessing the qualitative characteristics of selected studies, literature is further evaluated for eligibility for quantitative and qualitative analysis.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

Research articles which expressed efficacy rate of the six vaccines (Janssen, Moderna, Astrazeneca, Gamaleya Sputnik 5, Pfizer, and SinoVac), the total number of countries that approved a certain vaccine, efficacy of vaccines in omicron and delta variant, and lastly, the side effects associated with each vaccine are incorporated to come up with results that aligned to the objectives.

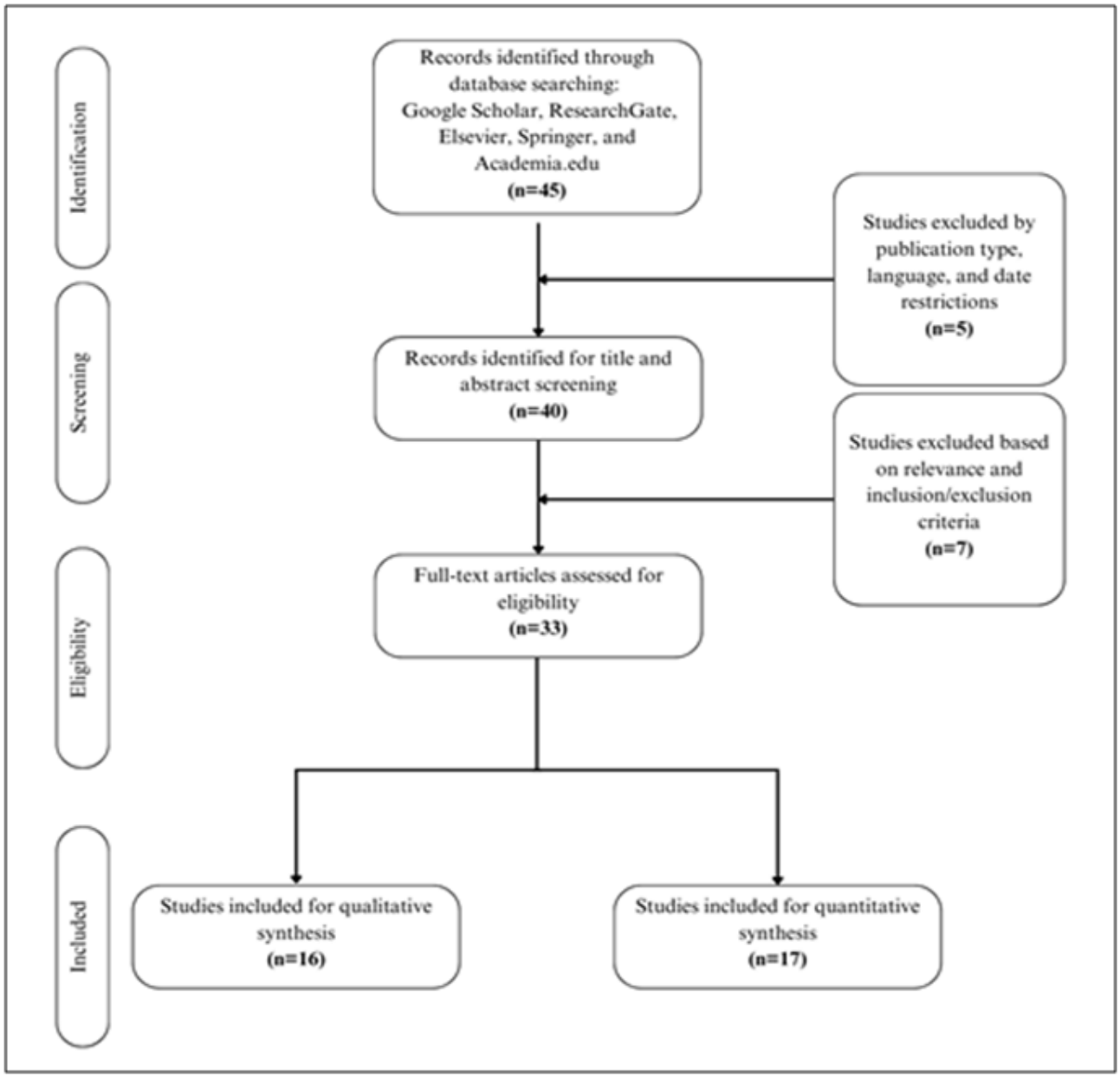

Fig. 1: Different Stages of Study Selections and Results Practiced in the PRISMA Flow Diagram.

III. RESULT AND DISCUSSION

❖ *Qualitative Results*

Sixteen gathered papers were used to investigate the side effects of each vaccine. Six vaccines were used. Three of them have been identified as viral vector vaccines, two are RNA-based vaccines, while the remaining one is inactivated vaccine.

The table displays the vaccine type, doses and shots, and its side effects (See in Table 1).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

Table 1. Comparing COVID-19 Vaccines: Types, Doses, and Side Effects.

Vaccine	Vaccine Type	Doses/Shot	Side Effects
Gamaleya Sputnik 5	Viral Vector Vaccine [2]	2 doses [1] 21 days apart; 0.5 mL each dose [6]	- Pain on the injection site - Hyperthermia - Swelling [6]
Janssen	Viral Vector Vaccine [2]	Single shot; 0.5 mL [6]	- Injection site pain - Redness of the skin and swelling - Tiredness - Headache - Muscle pain - Chills - Fever - Nausea [6]
Moderna	RNA-based Vaccine [2]	2 doses, 28 days apart [7]; 0.5 mL [6]	- Injection site pain - Fatigue - Headache - Muscle Pain - Chills - Joint pain [8]
Oxford AstraZeneca	Viral Vector Vaccine [2]	2 doses, 42 days apart, 0.5 mL [6]	- Injection site pain and tenderness - Fatigue - Headache - Feverishness - Myalgia, malaise - Pyrexia, chills - Arthralgia, nausea [6]
Pfizer-BioNTech	RNA-based Vaccine [2]	2 doses, 21 days apart [4]; 0.3 mL [6]	- Short-term mid-to-moderate pain at injection site - Fatigue - Headache - Muscle pain - Chills - Joint pain - Nausea - Feeling Unwell - Swollen Lymph node -Non-severe allergic reactions - diarrhea, vomiting [6]

A. Severe Acute Respiratory Syndrome CoronaVirus 2 and its Vaccines

Severe Acute Respiratory Syndrome CoronaVirus 2, also known as SARS-CoV-2, is the virus that causes a respiratory disease called CoronaVirus Disease 19 (COVID-19), a highly transmissible and pathogenic disease that emerged in late 2019 and has caused a pandemic that threatens human health and public safety (Hu, B., et al., 2020). One of the government responses to the widespread virus and lowering the rapid mortality rate, emergency authorization to use urgent vaccines to the society, was implemented. One of the pioneer vaccines that arose during the beginning of the pandemic are Pfizer-BioNTech, Moderna, Gamaleya Sputnik 5, and so on. As these vaccines gave an emergency authorization for public use, the vaccines underwent an immediate phase 3 clinical trial before being publicized. Consequently, due to the urgency of the vaccine, numerous people were becoming hesitant to be vaccinated by these vaccines. The study aims to determine the efficacy of the selected vaccines, namely, Gamaleya Sputnik 5, Janssen, Moderna, Oxford AstraZeneca, Pfizer-BioNTech, and SinoVac CoronaVac.

B. Vaccine Types and the Shots and Doses Required

COVID-19 vaccines increase the immunity system, which creates antibodies enough to withstand and resist COVID-19. In creating vaccines, there are various ways on how the vaccine will work to generate antibodies. According to the Mayo Clinic (2024), with the messenger RNA (mRNA) vaccine, one of the types of vaccines that instructs cells on how to make the S protein found on the surface of

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

the COVID-19 virus, there will be the production of antibodies against the virus.

Pfizer-BioNTech and Moderna vaccines used the mRNA method (see in Table 1). For the Moderna vaccine, as a mRNA-based vaccine, the required shots are 2 shots with a 0.5 mL dose each; there is a 28-day interval before the second shot is injected (see in Table 1). While the other mRNA-based vaccine, the Pfizer-BioNTech, also required 2 shots with a 0.3 mL dose each and 21-day apart before the second shot. (See in Table 1).

Furthermore, one of the vaccine types is a viral vector vaccine. In accordance with the U.S. Department of Health and Human Services (2022), it uses a modified version of a different virus as a vector to deliver protection. The viral vector gives cells instructions to make copies of the COVID-19 S protein, which helps the immunity system to create antibodies. Among the selected vaccines, Gamaleya Sputnik 5, Janssen, and Oxford AstraZeneca vaccines are the viral vector vaccines. Gamaleya Sputnik 5 required 2 shots with 0.5 mL each, and there is a 21-day interval between shots, as a viral vector vaccine (see in Table 1). In the Janssen vaccine, there is only a single shot with 0.5 mL. Lastly, the required shots in Oxford AstraZeneca are 2 shots with 0.5 mL each, and the recommended interval is 42-day (see in Table 1). The only vaccine that uses an inactivated vaccine is the SinoVac CoronaVac. The inactivated vaccine, defined as a type of vaccine, uses the killed version of the germs that cause a disease. Also, according to Experimental Parasitology (2023), it is a vaccine that destroys parasites physically and chemically while retaining some of their integrity to get recognized by the immune system. The required shots in this type of vaccine is 2 shots with 0.5 mL each with the recommendation of 14 days interval to get the second shot (see in Table 1).

C. Side Effects of SARS-CoV-2 Vaccines

The side effects associated with SARS-CoV-2 vaccines are generally mild and temporary, often resolving within a few days. Common reactions include pain, redness, and swelling at the injection site, as well as fatigue, headache, muscle pain, and fever. While less common side effects may include nausea, chills, and joint pain, severe allergic reactions are rare. The specific side effects may vary slightly between different vaccine types, but the overall profile of side effects is similar across all approved vaccines.

Viral vector vaccines, such as Sputnik V, Janssen, and AstraZeneca, tend to have a higher rate of injection site reactions and general symptoms like fatigue and headache. RNA-based vaccines, such as Moderna and Pfizer-BioNTech, often have a similar profile of side effects, with a focus on injection site reactions and general symptoms. Inactivated vaccines, like Sinovac, may have a slightly different range of side effects, including more frequent reports of dizziness and upper arm pain.

It is important to note that the experience of side effects can vary greatly from person to person, and the severity and duration of symptoms can differ. In general, the benefits of COVID-19 vaccination outweigh the risks of potential side effects.

❖ *Quantitative Results*

The research examined 17 studies on COVID-19 vaccines. These studies looked at how effective the vaccines were, which countries approved them, and how well they worked against variants like Delta and Omicron.

The table summarizes the key findings about vaccine effectiveness, approvals, and variant response (See in Table 2).

Table 2. COVID-19 Vaccine Country Approval and Efficacy Rates.

Vaccine	Approved Countries	Efficacy Rate
Gamaleya Sputnik 5	74 countries	91% [6]
Janssen	113 countries	85.4% [6]
Moderna	88 countries	94.5% [6]
Oxford AstraZeneca	149 countries	76% [6]
Pfizer-BioNTech	149 countries	95% [3]
SinoVac CoronaVac	56 countries	78% [6]

A. Efficacy of the Selected Vaccines

The provided graph compares the efficacy rates of six different COVID-19 vaccines in their Phase three (3) clinical trial: Gamaleya Sputnik 5, Janssen, Moderna, Oxford AstraZeneca, Pfizer-BioNTech, and SinoVac CoronaVac. The graph shows Moderna and Pfizer-BioNTech exhibit the highest efficacy rates, nearing 95% (See Fig. 2). These vaccines demonstrate strong protection against COVID-19, making them some of the most reliable vaccines in efficacy. Gamaleya Sputnik 5 follows closely with an efficacy rate of around 91%, which provides substantial protection against the virus. In contrast, Janssen, shows a moderately high efficacy rate, slightly exceeding 85.4% (See Fig. 2). While effective, it does not reach the same level as Moderna, Pfizer-BioNTech, and Gamaleya Sputnik5. SinoVac CoronaVac has an efficacy rate of 78% (See Fig. 2), which is lower than others, and still offers significant protection, particularly in preventing severe cases of the virus. Lastly, the Oxford AstraZeneca has the lowest efficacy rate in this comparison, falling slightly to 76% (See Fig. 2), although it has the lowest efficacy rate from others, it still contributes to mitigating the impact of COVID-19, especially against severe infections.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

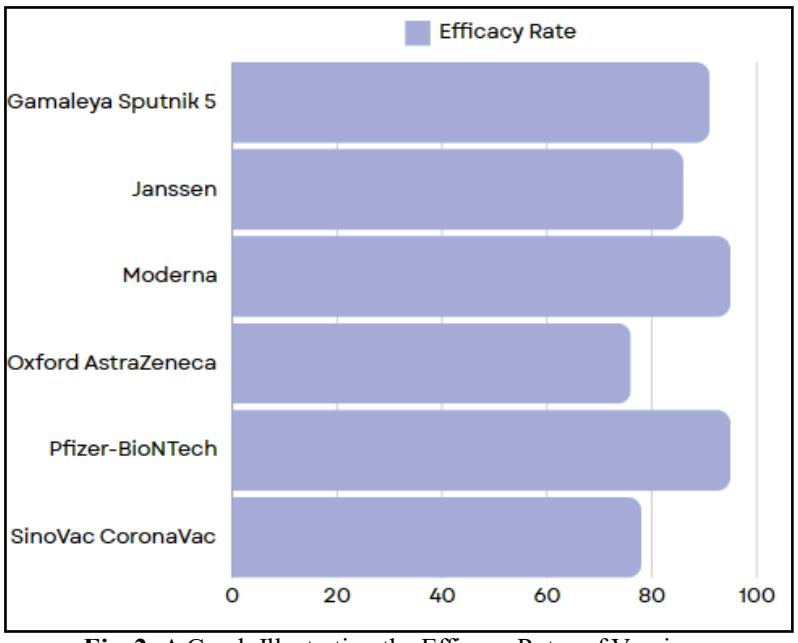

Fig. 2: A Graph Illustrating the Efficacy Rates of Vaccines.

B. Worldwide Countries Vaccines Approved

Due to the quickly widespread of COVID-19 virus, several countries immediately inquired and accepted the pioneer vaccines in the beginning phase of the pandemic to control and prevent the accelerated growth of the infections of the virus. However, there are some countries that are hesitant to approve and allow the vaccines to be used in public. In accordance with the gathered scientific articles and government official websites, there are 74 countries worldwide that approved the Gamaleya Sputnik 5 entering their premises, 113 countries allowed the Janssen vaccine to be publicly used, 88 countries accepted the Moderna vaccine, Oxford AstraZeneca and Pfizer-BioNTech has a same country approved which is 149 countries, and lastly the SinoVac CoronaVac approved in 56 countries (see Fig. 3).

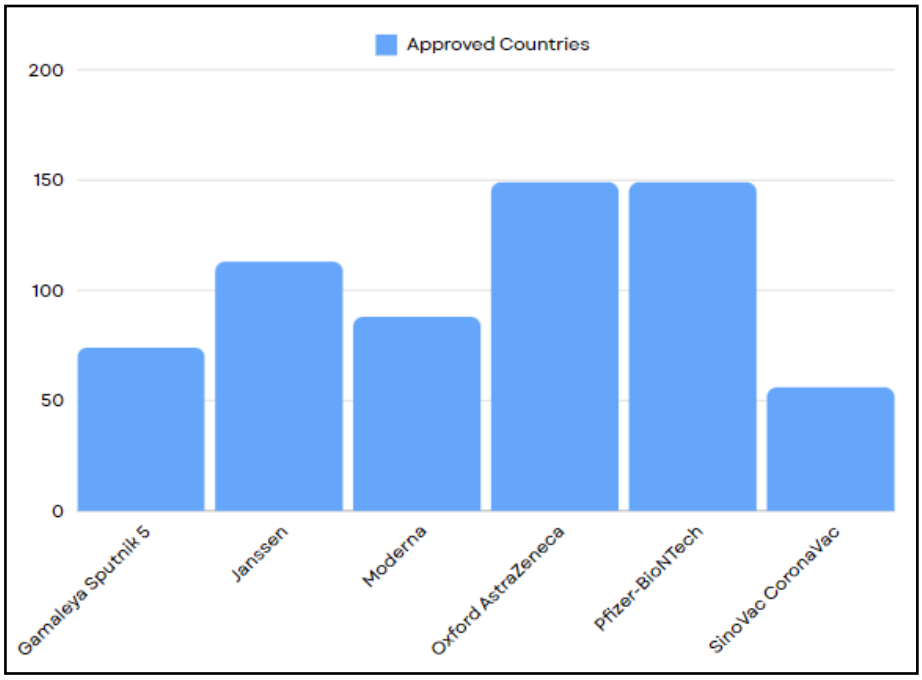

Fig. 3: A Graph Illustrating the Worldwide Countries Vaccines Approved.

C. Severe Acute Respiratory Syndrome CoronaVirus 2 (SARS-CoV-2) Variants

COVID-19 variants have significantly impacted the course of the pandemic, with Omicron and Delta emerging as two of the strains with comparable mortality rate and highly transmissible (Radhakrishnan et al., 2023). The Delta variant, first identified in India in late 2020, became globally dominant by mid-2021 due to its heightened transmissibility compared to earlier strains (Katella, 2023). It was associated with more severe illness, particularly among unvaccinated individuals, leading to increased hospitalizations and death in many regions. The Omicron variant, detected in November 2021 in South Africa, quickly surpassed

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

Delta as the dominant strain worldwide (Gbaguidi et al., 2023). While generally causing less severe illness, Omicron's exceptional transmissibility and ability to partially evade immunity from prior infection or vaccination resulted in unprecedented case surges globally.

D. COVID-19 Omicron Variant

The effectiveness of various COVID-19 vaccines against these variants has been a vital area of study, with data showing significant variations across different vaccines, timeline, and variants. For the Omicron Variant, initial vaccine effectiveness after two (2) doses (measured 2-4 weeks post-vaccination) showed moderate results of efficacy. The mRNA vaccines, Pfizer-BioNTech and Moderna, demonstrated the highest initial effectiveness at 65.5% and 75.1% respectively (See Fig. 4). The AstraZeneca vaccine showed lower but still notable effectiveness at 48.9%, while Sinovac's Coronavac had the lowest initial effectiveness at 18.2% (see Fig. 4). These figures highlight the varying degrees of efficacy offered by different vaccine technologies against the mutated Omicron variant. However, the data reveals a concerning trend of waning efficacy over time. After 25 or more weeks post-vaccination, effectiveness dropped drastically for all vaccines. Pfizer-BioNTech and Moderna vaccines showed effectiveness plummet to 8.8% and 14.9% respectively, while AstraZeneca became ineffective (See Fig. 4). This rapid decline in efficacy highlights the need for booster doses to maintain efficacy of vaccines against Omicron. Furthermore, the data indicates the importance of combining the right vaccine and booster to achieve higher efficiency.

The introduction of booster doses significantly recovered the efficacy level, albeit to varying degrees. When measured 2-4 weeks after the booster, effectiveness ranged from 62.4% to 73.9% for most vaccine combinations. Particularly, the Sinovac vaccine that has an undefined booster showed a remarkable increase in efficacy to 97.5% (See Fig. 4). However, this recovered effectiveness was often short-term. After 10 or more weeks, most boosters showed reduced effectiveness or became ineffective, with only the AstraZeneca vaccine boosted by Moderna maintaining moderate effectiveness at 60.9% and Sinovac with undefined booster at 65.2% (See Fig. 4).

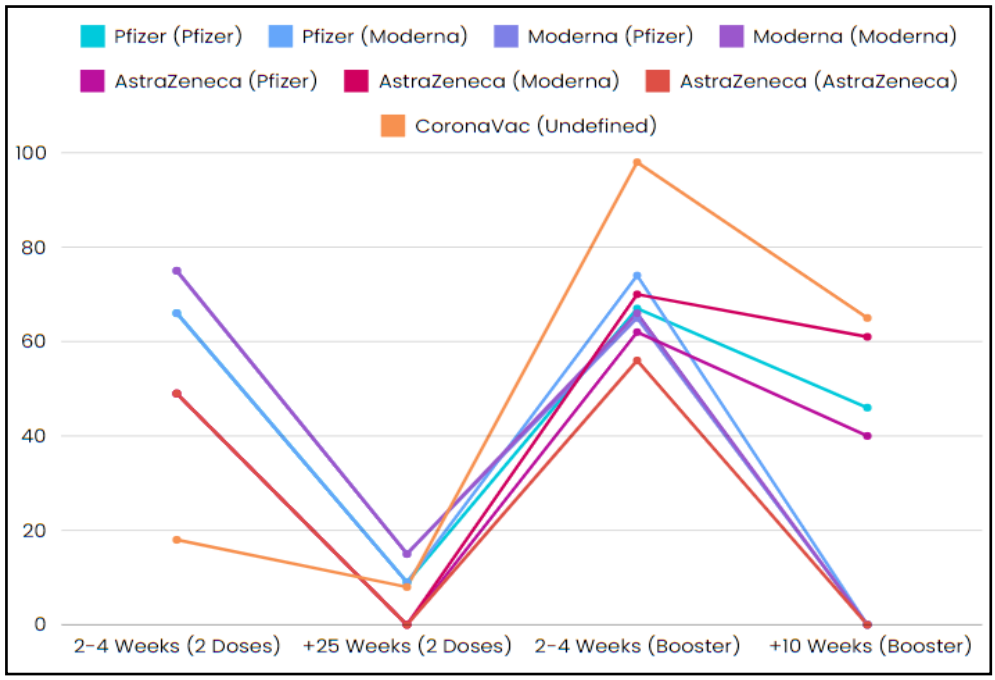

Fig. 4: A Graph Shows the Effectiveness of Vaccines in Omicron Variant.

E. COVID-19 Delta Variant

The data for the Delta variant shows a somewhat different trend, generally showing higher vaccine effectiveness compared to Omicron. Initial effectiveness after two (2) doses was similar to Omicron for mRNA vaccines (Pfizer-BioNTech and Moderna) and viral vector vaccine (AstraZeneca) but particularly higher for AstraZeneca Sinovac with 59.0%. The pattern of waning immunity was similar to Omicron, with significant decreases in effectiveness to ineffective after 25 or more weeks (See Fig. 5). Booster doses proved highly effective against Delta, with most combinations showing over 80% effectiveness. The Pfizer booster, in particular, demonstrated high effectiveness when combined with various primary vaccine series. Long-term booster effectiveness data for Delta is limited, but the available information suggests better efficacy compared to Omicron, with the Pfizer booster for AstraZeneca maintaining 88.1% effectiveness even after 10 or more weeks (See Fig. 5).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

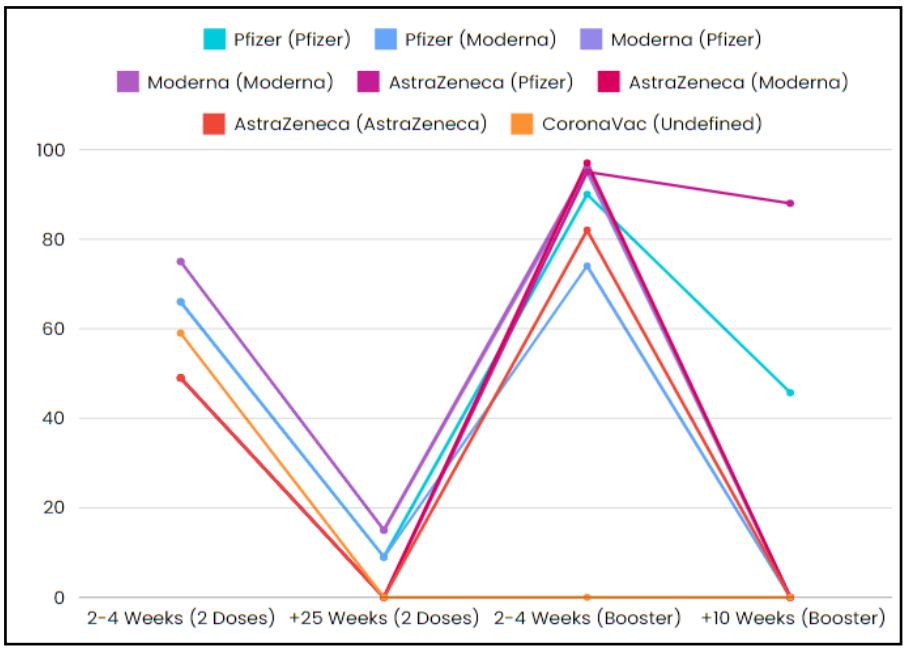

Fig. 5: A Graph Shows the Effectiveness of Vaccines in Delta Variant.

This comprehensive analysis of vaccine effectiveness against Omicron and Delta variants highlights the dynamic nature of immunity against SARS-CoV-2. It highlights the crucial role of booster doses in maintaining protection, particularly against the immune-evasive Omicron variant. The data also emphasizes the need for continued vaccine development and administration strategies to address the evolving threat of new variants. As the virus continues to mutate, ongoing research and surveillance will be vital in informing public health strategies and vaccine development efforts to effectively combat the COVID-19 issue.

IV. CONCLUSION

This systematic review analyzes the efficacy of the selected COVID-19 vaccines, namely Gamaleya Sputnik 5, Janssen, Moderna, Oxford AstraZeneca, Pfizer-BioNTech, and SinoVac CoronaVac. In qualitative analysis of the scientific articles, most of the recommended shots and doses of the vaccines are the same, which are 2 doses with 0.5 mL each shot. Generally, when it comes to side effects of the vaccines, there is a similarity of having pain on the injection site, headache, muscle pain, and chills. For quantitative analysis, the vaccines that have the highest country approval are Oxford AstraZeneca and Pfizer-BioNTech, with 149 approved countries over the world. Moreover, when it comes to efficacy rate, the highest are the Pfizer-BioNTech with 95%, followed by the Moderna vaccine with 94.5% efficacy rate. In the later part of the systematic review, the effectiveness of the vaccines along with booster shots in Omicron and Delta variants. The most effective vaccine in the Omicron variant is the Oxford AstraZeneca, with effectiveness after 2 doses of 48.9%, and the booster shot of the Moderna enhances the effectiveness with 60.9%.

Meanwhile, in the Delta variant, the most effective vaccine is AstraZeneca with 48.9% after 2 doses; however, the booster shot of Pfizer-BioNTech enhances the effectiveness that elevates to 95.4%, and even after more than 10 weeks after the booster shot, the effectiveness is still high with 88.1%. Therefore, the data also emphasizes the need for continued vaccine development and administration strategies to address the evolving threat of new variants. As the virus continues to mutate, ongoing research and surveillance will be vital in informing public health strategies and vaccine development efforts to effectively combat the COVID-19 issue.

ACKNOWLEDGEMENT

We would like to express our deepest gratitude to all those who have supported and contributed to the successful completion of this research. Firstly, we are grateful to our professor, Ms. Gecelene Estorico, for her guidance, encouragement, and insight feedback throughout this systematic review.

We are particularly thankful to our group members – Claire G. Beringuela, Dianna Jhent S. Cullamar, Levy Donor, and Czedrick Khien S. Mongaya – for their dedication, teamwork, and collective efforts throughout the systematic review process. Their hard work and commitment were vital in ensuring the success of this paper.

Lastly, we extend our appreciation to coffee, our constant companion during long hours of research and writing, for keeping us energized and focused throughout this journey.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

REFERENCES

[1]. Andrews, N., Stowe, J., Kirsebom, F., Toffa, S., Rickeard, T., Gallagher, E., ... & Lopez Bernal, J. (2022). Covid-19 vaccine effectiveness against the Omicron (B. 1.1. 529) variant. New England Journal of Medicine, 386(16), 1532-1546. DOI: 10.1056/NEJMoa211945

[2]. Bartsch, S. M., O'Shea, K. J., Ferguson, M. C., et al. (2020). Vaccine efficacy needed for a COVID-19 coronavirus vaccine to prevent or stop an epidemic as the sole intervention. American Journal of Preventive Medicine, 59(4), 493–503. https://doi.org/10.1016/j.amepre.2020.06.011

[3]. Bernal, J. L., Andrews, N., Gower, C., et al. (2021). Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on covid-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. BMJ, n1088. https://doi.org/10.1136/bmj.n1088

[4]. Cababan, M. A. L., Catane, G. V., & Alava, W. G. (2021). Covid-19 Vaccines in the Philippines: A Meta-analysis. Health Econ, 7(7), 179. doi: 10.35248/2471-268x.21.7.

[5]. Cai, C., Peng, Y., Shen, E., et al. (2021). A comprehensive analysis of the efficacy and safety of COVID-19 vaccines. Molecular Therapy, 29(9), 2794–2805. https://doi.org/10.1016/j.ymthe.2021.08.001

[6]. Chohan, H. K., Jamal, A., Mubeen, M., et al. (2023). The Common Systemic and Local Adverse Effects of the Sinovac COVID-19 Vaccine: An Observational Study From Pakistan. Cureus, 15(5). https://doi.org/10.7759/cureus.38564

[7]. Ciotti, M., Ciccozzi, M., Terrinoni, A., Jiang, W., Wang, C., & Bernardini, S. (2020). The COVID-19 pandemic. Critical Reviews in Clinical Laboratory Sciences, 57(6), 365–388. https://doi.org/10.1080/10408363.2020.1783198

[8]. COVID-19 vaccines. (2023, October 19). https://www.who.int/westernpacific/emergencies/covid-19/covid-19-vaccines

[9]. Deplanque, D., & Launay, O. (2021). Efficacy of COVID-19 vaccines: From clinical trials to real life. Therapies, 76(4), 277–283. https://doi.org/10.1016/j.therap.2021.05.004

[10]. Different types of COVID-19 vaccines: How they work. (2024,September 7). Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/coronavirus/in-depth/different-types-of-covid-19-vaccines/art-20506465

[11]. Doroftei, B., Ciobica, A., Ilie, O., et al. (2021). Mini-Review discussing the reliability and efficiency of COVID-19 vaccines. Diagnostics, 11(4), 579. https://doi.org/10.3390/diagnostics11040579

[12]. Gomes, I. A., Soares, P., Rocha, J. V., Gama, A., Laires, P. A., Moniz, M., ... & Nunes, C. (2022). Factors associated with COVID-19 vaccine hesitancy after implementation of a mass vaccination campaign. Vaccines, 10(2), 281. https://doi.org/10.3390/vaccines10020281

[13]. Haas, E. J., Angulo, F. J., McLaughlin, J. M., Anis, E., Singer, S. R., Khan, F., ... & Alroy-Preis, S. (2021). Impact and effectiveness of mRNA BNT162b2 vaccine against SARS-CoV-2 infections and COVID-19 cases, hospitalisations, and deaths following a nationwide vaccination campaign in Israel: an observational study using national surveillance data. The Lancet, 397(10287), 1819-1829. . DOI: 10.1016/S0140-6736(21)00947-8

[14]. Hahn, W. O., & Wiley, Z. (2022). COVID-19 vaccines. Infectious Disease Clinics of North America, 36(2), 481. doi: 10.1016/j.idc.2022.01.008

[15]. Hu, B., Guo, H., Zhou, P., & Shi, Z. (2020). Characteristics of SARS-COV-2 and COVID-19. Nature Reviews Microbiology, 19(3), 141-154. https://www.nature.com/articles/s41579-020-00459-7

[16]. Huang, Z., Su, Y., Zhang, T. et al. A review of the safety and efficacy of current COVID-19 vaccines. Front. Med. 16, 39–55 (2022). https://doi.org/10.1007/s11684-021-0893-y

[17]. Iacobucci, G. (2021). Covid-19: Two doses of Pfizer vaccine are "highly effective" against infection, hospital admission, and death, study finds.. https://doi.org/10.1136/bmj.n1164

[18]. IKezia, V. A. L. E. R. I. E., & Ramatillah, D. L. (2022). Intensive monitroing of sinovac vaccine for safety and efficacy among Indonesian population. Int. J. Appl. Pharm, 14, 44-48. DOI: https://dx.doi.org/10.22159/ijap.2022.v14s2.44748

[19]. Katella, K. (2024, September 3). Comparing the COVID-19 vaccines: How are they different? Yale Medicine. https://www.yalemedicine.org/news/covid-19-vaccine-comparison

[20]. Kaznadzey, A., Tutukina, M., Bessonova, T., Kireeva, M., & Mazo, I. (2022). BNT162b2, mRNA-1273, and Sputnik V vaccines induce comparable immune responses on a par with severe course of COVID-19. Frontiers in Immunology, 13, 797918. doi: 10.3389/fimmu.2022.797918

[21]. Kim, J.H., Marks, F. & Clemens, J.D. Looking beyond COVID-19 vaccine phase 3 trials. Nat Med 27, 205–211 (2021). https://doi.org/10.1038/s41591-021-01230-y

[22]. Krammer, F. (2020). SARS-CoV-2 vaccines in development. Nature, 586(7830), 516–527. https://doi.org/10.1038/s41586-020-2798-3

[23]. Li, X. N., Huang, Y., Wang, W., Jing, Q. L., Zhang, C. H., Qin, P. Z., ... & Zhong, N. S. (2021). Effectiveness of inactivated SARS-CoV-2 vaccines against the Delta variant infection in Guangzhou: a test-negative case–control real-world study. Emerging microbes & infections, 10(1), 1751-1759. https://doi.org/10.1080/22221751.2021.1969291

[24]. Mahor, H., Mukherjee, A., Sarkar, A., & Saha, B. (2023). Anti-leishmanial therapy: Caught between drugs and immune targets. Experimental Parasitology, 245, 108441. https://doi.org/10.1016/j.exppara.2022.108441

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV618

[25]. Meo, S. A., Bukhari, I. A., Akram, J., Meo, A. S., & Klonoff, D. C. (2021). COVID-19 vaccines: comparison of biological, pharmacological characteristics and adverse effects of Pfizer/BioNTech and Moderna Vaccines. European Review for Medical & Pharmacological Sciences, 25(3).DOI: 10.26355/eurrev_202102_24877
[26]. Moghadas, S. M., Vilches, T. N., Zhang, K., et al. (2021). The impact of vaccination on coronavirus disease 2019 (COVID-19) outbreaks in the United States. Clinical Infectious Diseases, 73(12), 2257–2264. https://doi.org/10.1093/cid/ciab079
[27]. Philippines – COVID19 vaccine tracker. (n.d.). https://covid19.trackvaccines.org/country/philippines/
[28]. Reynolds, L., Dewey, C., Asfour, G., et al. (2023). Vaccine efficacy against SARS-CoV-2 for Pfizer BioNTech, Moderna, and AstraZeneca vaccines: a systematic review. Frontiers in Public Health, 11. https://doi.org/10.3389/fpubh.2023.1229716
[29]. Ripabelli, G., Tamburro, M., Buccieri, N. et al. Active Surveillance of Adverse Events in Healthcare Workers Recipients After Vaccination with COVID-19 BNT162b2 Vaccine (Pfizer-BioNTech, Comirnaty): A Cross-Sectional Study. J Community Health 47, 211–225 (2022). https://doi.org/10.1007/s10900-021-01039-3
[30]. Tavilani, A., Abbasi, E., Ara, F. K., et al. (2021). COVID-19 vaccines: Current evidence and considerations. Metabolism Open, 12, 100124. https://doi.org/10.1016/j.metop.2021.100124
[31]. Tigas, K.A. (2021). Storage and Dosage Requirements, Efficacy, Safety, and Adverse Effects of 6 COVID-19 Vaccines: A Comparative Analysis. https://doi.org/10.13140/RG.2.2.10023.36001.
[32]. Yin, Y., Li, X., Qian, C., Cheng, B., Lu, F., & Shen, T. (2022). Antibody efficacy of inactivated vaccine boosters (CoronaVac) against Omicron variant from a 15-month follow-up study. The Journal of Infection, 85(4), e119. doi: 10.1016/j.jinf.2022.06.018
[33]. Radhakrishnan, N., Liu, M., Idowu, B., et al. (2023). Comparison of the clinical characteristics of SARS-CoV-2 Delta (B.1.617.2) and Omicron (B.1.1.529) infected patients from a single hospitalist service. BMC Infectious Diseases, 23(1). https://doi.org/10.1186/s12879-023-08714-x
[34]. Katella, K. (2023, September 1). Omicron, Delta, Alpha, and more: What to know about the coronavirus variants. Yale Medicine. https://www.yalemedicine.org/news/covid-19-variants-of-concern-omicron
[35]. Gbaguidi, G. N., Aubert, L., Schaeffer, J., et al. (2023). Emergence and Evolution of the Omicron SARS-CoV-2 Variant in the Island of Martiniqque. Infectious Diseases Now, 53 (4), 104690. https://doi.org/10.1016/j.idnow.2023.104690